

### **What is claimed is:**

- [Claim 1]** 1. A bipolar plate for an electrochemical cell, comprising:  
a first layer having a first plurality of through channels oriented in a first direction;  
a second layer having a second plurality of through channels oriented in a second different direction;  
a third layer disposed between and bonded to the first and second layers, the third layer having a first set of header channels in fluid communication with the first plurality of channels, and a second set of header channels in fluid communication with the second plurality of channels;  
a first inlet port and a first outlet port in fluid communication with the first set of header channels; and  
a second inlet port and a second outlet port in fluid communication with the second set of header channels;  
wherein the bonded third layer prevents fluid communication between the first plurality of channels and the second plurality of channels.
- [Claim 2]** 2. The bipolar plate of Claim 1, wherein:  
the first direction is oriented about 90 degrees to the second direction.
- [Claim 3]** 3. The bipolar plate of Claim 1, wherein:  
the first inlet port and the first outlet port are diagonally disposed with respect to a fluid flow therebetween; and  
the second inlet port and the second outlet port are diagonally disposed with respect to a fluid flow therebetween.
- [Claim 4]** 4. The bipolar plate of Claim 1, wherein:  
the first layer has a first thickness;  
each of the first plurality of channels has a first width;  
the first width is equal to or greater than about the first thickness and equal to or less than about three times the first thickness;  
the second layer has a second thickness;

each of the second plurality of channels has a second width; and  
the second width is equal to or greater than about the second thickness and  
equal to or less than about three times the second thickness.

**[Claim 5]** 5. The bipolar plate of Claim 1, wherein:  
the first layer has a first thickness;  
each of the first plurality of channels has a first width;  
the first width is equal to or greater than about 1.5 times the first thickness;  
the second layer has a second thickness;  
each of the second plurality of channels has a second width; and  
the second width is equal to or greater than about 1.5 times the second  
thickness.

**[Claim 6]** 6. The bipolar plate of Claim 4, wherein:  
the first width is greater than the second width.

**[Claim 7]** 7. The bipolar plate of Claim 5, wherein:  
the first width is greater than the second width.

**[Claim 8]** 8. The bipolar plate of Claim 1, wherein:  
the first set of header channels comprises a first through channel extending from  
the first inlet port, and a second through channel extending from the first outlet port;  
and  
the second set of header channels comprises a third through channel extending  
from the second inlet port, and a fourth through channel extending from the second  
outlet port.

**[Claim 9]** 9. The bipolar plate of Claim 8, wherein:  
the first, second, third, and fourth, through channels are isolated from each  
other.

**[Claim 10]** 10. The bipolar plate of Claim 1, wherein:  
the third layer is diffusion bonded to the first and second layers.

**[Claim 11]** 11. The bipolar plate of Claim 1, wherein:  
at least one of the first set of header channels and the second set of header channels of the third layer comprises a plurality of header channels.

**[Claim 12]** 12. The bipolar plate of Claim 1, wherein:  
the first, second, and third, layers are made from titanium, zirconium, stainless steel, or any combination comprising at least one of the foregoing materials.

**[Claim 13]** 13. An electrochemical cell comprising:  
a plurality of membrane-electrode-assemblies (MEAs) alternatively arranged with a plurality of flow field members between a first cell separator plate and a second cell separator plate;  
wherein at least one of the plurality of flow field members comprises a bipolar plate, the bipolar plate comprising:  
a first layer having a first plurality of through channels oriented in a first direction;  
a second layer having a second plurality of through channels oriented in a second different direction;  
a third layer disposed between and bonded to the first and second layers, the third layer having a first set of header channels in fluid communication with the first plurality of channels, and a second set of header channels in fluid communication with the second plurality of channels;  
a first inlet port and a first outlet port in fluid communication with the first set of header channels; and  
a second inlet port and a second outlet port in fluid communication with the second set of header channels;  
wherein the bonded third layer prevents fluid communication between the first plurality of channels and the second plurality of channels.

**[Claim 14]** 14. The bipolar plate of the electrochemical cell of Claim 13, wherein:

the first layer has a first thickness;  
each of the first plurality of channels has a first width;  
the first width is equal to or greater than about the first thickness and equal to or less than about three times the first thickness;  
the second layer has a second thickness;  
each of the second plurality of channels has a second width; and  
the second width is equal to or greater than about the second thickness and equal to or less than about three times the second thickness.

**[Claim 15]** 15. The bipolar plate of the electrochemical cell of Claim 14, wherein:

the first width is greater than the second width.

**[Claim 16]** 16. The electrochemical cell of Claim 15, wherein:  
each MEA comprises an oxygen electrode and a hydrogen electrode; and  
the first layer of the bipolar plate is proximate the oxygen electrode.

**[Claim 17]** 17. The bipolar plate of the electrochemical cell of Claim 15, wherein:

the third layer is diffusion bonded to the first and second layers.

**[Claim 18]** 18. The electrochemical cell of Claim 13, wherein the first plurality of through channels define a first active area, and further comprising:

a fluid flow seal about the first active area; and  
a fluid flow seal about each of the inlet and outlet ports at the first layer.

**[Claim 19]** 19. The electrochemical cell of Claim 18, wherein the second plurality of through channels define a second active area, and further comprising:

a fluid flow seal about the second active area; and  
a fluid flow seal about each of the inlet and outlet ports at the second layer.

**[Claim 20]** 20. An electrochemical cell comprising:  
a plurality of membrane-electrode-assemblies (MEAs) alternatively arranged with a plurality of flow field members between a first cell separator plate and a second cell separator plate;

wherein at least one of the plurality of flow field members comprises a bipolar plate, the bipolar plate comprising:

first, second, and third, layers bonded together to form a laminated arrangement, the first layer having a first set of through channels, the second layer having a second set of through channels, and the third layer having a third and a fourth set of through channels, the third layer being disposed between the first and second layers;

the laminated arrangement having first and second inlet ports, and first and second outlet ports;

wherein the first inlet port, the first set of through channels, the third set of through channels, and the first outlet port, define a first fluid flow path;

wherein the second inlet port, the second set of through channels, the fourth set of through channels, and the second outlet port, define a second fluid flow path; and

wherein the bonded layers of the laminated arrangement prevent fluid communication between the first fluid flow path and the second fluid flow path.

**[Claim 21]** 21. The bipolar plate of the electrochemical cell of Claim 20, wherein:

the third layer is diffusion bonded to the first and second layers.

**[Claim 22]** 22. The bipolar plate of the electrochemical cell of Claim 21, wherein:

the first, second, and third, layers are made from titanium, zirconium, stainless steel, or any combination comprising at least one of the foregoing materials.